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Low transverse energy jet cross section at LHC

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Abstract: I exhibit some simple features of the one jet inclusive cross section at the LHC.

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1 The cross section

I have used the EKS jet program (version 4.21) to calculate the inclusive cross section

$$\frac{d\sigma(|y| < y_{\max})}{dE_T} \tag{1.1}$$

at the LHC. I choose the Snowmass cone jet definition.[1] I take

$$\begin{aligned} y_{\max} &= 1 \\ \mu_{\rm UV} &= 0.5\, E_T \\ \mu_{\rm coll} &= 0.5\, E_T \\ \sqrt{s} &= 14000 \text{ GeV} \end{aligned} \tag{1.2}$$

The program does not perform very well at E_T values smaller than 100 GeV. Nevertheless, in an hour and a half of running time I get about 10% errors at $E_T = 20$ GeV and about 3% errors at $E_T = 100$ GeV. The statistical error in the lowest bin, 10 GeV, is 100%, so this bin should be ignored. I checked the renormalization and factorization scale dependence and found rather strange results for $E_T < 50$ GeV. Also results for $1 < |y| < 3$ suggests problems for $E_T < 50$ GeV. Thus, although I show results for the suspect range, one should really imagine that we work by extrapolation of results for $E_T > 50$ GeV into the lower range.

I find that the result fits pretty well to

$$\frac{d\sigma(|y| < y_{\max})}{dE_T} \approx \frac{C\,A}{E_{T,0}} \left(\frac{E_{T,0}}{E_T}\right)^{A+1} \tag{1.3}$$

with

$$\begin{aligned} E_{T,0} &= 10 \text{ GeV} \\ C &= 3.6\,\text{mb} \\ A &= 3.66 \end{aligned} \tag{1.4}$$

[1] There is no "$y_{\rm sep}$." One eliminates $y_{\rm sep}$ by setting $y_{\rm sep} = 2$ in the program.

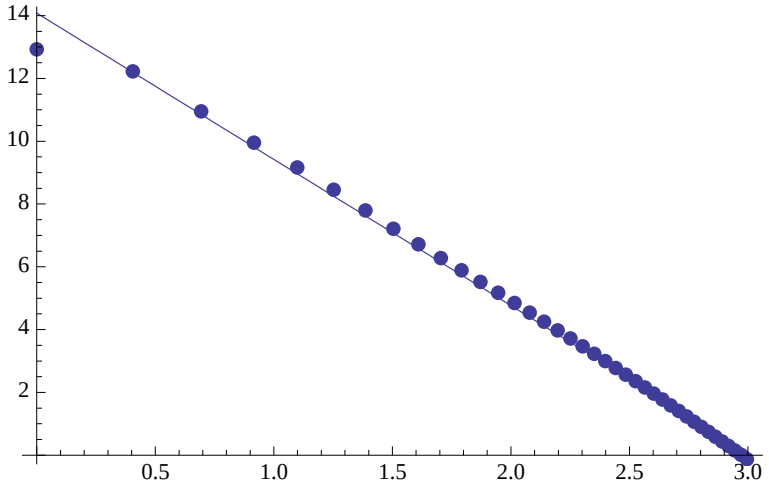

Figure 1: Cross section $d\sigma/dE_T$ for $|y| < 1$ at LHC. The vertical axis is $\log(d\sigma/dE_T)$. The horizontal axis is $\log(dE_T/E_{T,0})$. The points cover the range 10 GeV $< E_T <$ 200 GeV in increments of 5 GeV.

The fit is shown in Fig. 1.

If we integrate this result from $E_{T,\min}$ to ∞ we get

$$\sigma(|y| < y_{\max}, E_T > E_{T,\min}) \approx C \left(\frac{E_{T,0}}{E_{T,\min}}\right)^A \tag{1.5}$$

From the Particle Data Group summary, I find that the pp total cross section at 14 TeV is a bit over 100 mb. Thus the average number of jets with $E_T > 10$ GeV in the rapidity window $|y| < 1$ is about 0.04. (Mostly an event with one jet in the rapidity window will have another, so the fraction of events with an event in the rapidity window is about 0.02.)

2 Average number of mini-jets in a hard event

I note that any event that produces a hard interaction (anything with a scale $Q >$ 100 GeV) is likely to be a more central event than the average. Such events are more likely to produce mini-jets than the average event. Thus one might guess that the average number of minijets in a hard interaction event is

$$\langle N_{\rm jet}\rangle \approx F \times \frac{\sigma(|y| < y_{\max}, E_T > E_{T,\min})}{\sigma_{\rm tot}} \tag{2.1}$$

where the enhancement factor F is perhaps something like 2. That is

$$\langle N_{\rm jet}\rangle \approx \frac{F\,C}{\sigma_{\rm tot}} \left(\frac{E_{T,0}}{E_{T,\min}}\right)^A \tag{2.2}$$

where I use

$$\begin{aligned} \sigma_{\rm tot} &= 100 \text{ mb} \\ F &= 2 \end{aligned} \tag{2.3}$$

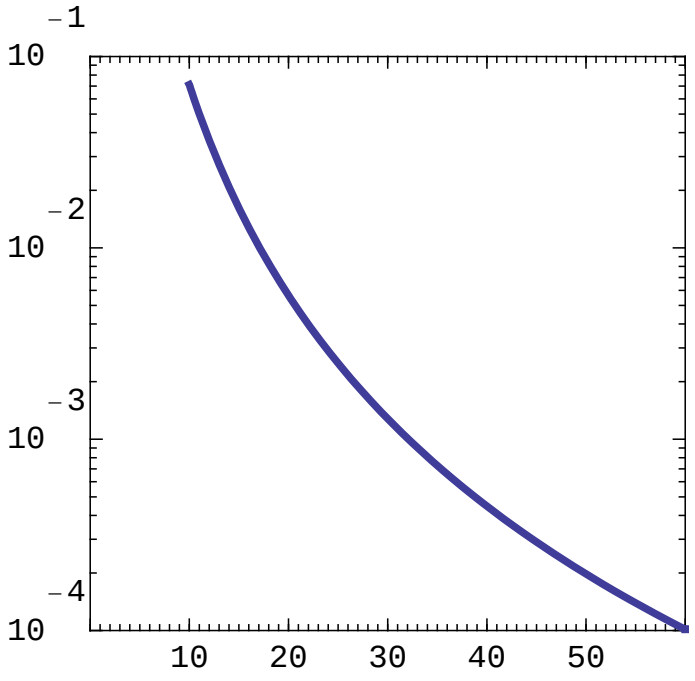

Figure 2: Fraction of central events with a hard interaction that has also a jet with $E_T > E_{T,\min}$ in the rapidity window $|y| < 1$ according to a rough model (with $F_0 = 1$). The vertical axis is the fraction. The horizontal axis is $E_{T,\min}$ in GeV.

A graph of this is shown in Fig. 2.

This is a pretty crude model. One could estimate F "theoretically" with a model of the density profile of the proton. One could also estimate it from the CDF data on double parton scattering.